EQUIPMENT DEVELOPMENT & TEST REPORT 7120-1

RESULTS OF FIELD TRIALS OF THE TREE EATER

A TREE AND BRUSH MASTICATOR

U.S. DEPARTMENT of AGRICULTURE
FOREST SERVICE
EQUIPMENT DEVELOPMENT CENTER
SAN DIMAS, CALIFORNIA

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Equipment Development and Test Report 7120

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RESULTS OF FIELD TRIALS OF THE TREE EATER, A TREE AND BRUSH MASTICATOR

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ABSTRACT

During 1963 a machine called the Tree Eater - designed to masticate woody vegetation from shrubs to trees - was brought to the attention of the Forest Service. This report presents the knowledge gained from a preliminary evaluation in 1964, the subsequent tests and field use.

These tests showed that the operating principle and general capability of the Tree Eater are good. The machine will contribute significantly to resource management programs involving release, thinning, slash disposal, fire hazard reduction, right-of-way clearing and clearing for type conversion for range or watershed management when operated on a selective basis. The machine does have definite limitations from the standpoints of terrain, operating maintenance, cost, and safety.

ACKNOWLEDGMENT

The Equipment Development Center, San Dimas, wishes to express its appreciation to the Southwestern Region, the Sitgreaves and Tonto National Forests, and, in particular, to the personnel of the Payson Ranger District - Andy Lindquist, District Ranger, and Bob Lincoln, operator of the Tree Eater - for their cooperation and assistance in conducting the demonstration and tests. Without this assistance it would have been impossible to successfully complete this test project.

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INTRODUCTION

The Forest Service has long been looking for better ways of clearing land for reforestation, range rehabilitation, fire hazard reduction, and improvement of watersheds. These clearing operations include disposal of logging slash, thinning of overstocked stands, and manipulation of undesirable trees and shrubs. Early in 1964 a commercially manufactured machine called the "Tree Eater" showed possibilities of doing these jobs effectively and was demonstrated to the Forest Service.

This report presents information gained from two tests and field use. The first test was a preliminary evaluation conducted in conjunction with a demonstration in May 1964 sponsored by the Southwestern Region on the Sitgreaves and Tonto National Forests. The second was a field test conducted during May 1966 by the Equipment Development Center, San Dimas, with the aid of personnel from the Payson Ranger District of the Tonto National Forest.

The purposes of the evaluations were to determine the range of possible applications of the Tree Eater for solving the various land-clearing problems, to determine its operating limits and possible mechanical weaknesses, and to establish production rates and costs.

DESCRIPTION OF TREE EATER

The machine is commercially available from the Tree Eater Corporation of Gurdon, Arkansas. Its cost is approximately $38,500 when supplied with a spare set of cutting arm assemblies, f.o.b. Gurdon. The complete unit weighs about 25,000 pounds.

Figure 1. Overall view of Tree Eater

The unit is essentially a front-end flail cutter powered by a 325 hp GMC Diesel engine mounted on a Case 750 Tractor with 18-inch tracks and torque converter drive. The cutting drum and engine balance each other on a frame that completely encompasses the tractor. The frame pivots on a crossbar located near the center of the tractor. The engine drives the cutter through a conventional manually operated plate clutch and multiple V-belt drive utilizing a midshaft or idler. Since the Tree Eater unit is a separate machine mounted on the tractor, it is possible to remove the unit - in an estimated six hours - and replace it with a dozer blade for fire control or other off-season work.

The actual cutting unit consists of a drum of about 30 inches in diameter and 72 inches in length, with four rows of cutting arms. The cutters, 70 in all, are mounted on four full-length hinge pins. Each cutter weighs 14 pounds. The operating speed of the drum is 1,800 rpm. When used for clearing, the flail cutters produce a clean 6-foot cleared swath.

Figure 2. Closeup of cutting drum showing flail cutters

During cutting and masticating operations, the height of the cutters above ground level can be varied from 0 to 8 inches and is controlled by skids located at the bottom of each side of the drum-bearing support frame. For traveling or special cutting, the height can be controlled hydraulically over a range of 0 to 27 inches above ground. To aid in pushing trees forward as they are cut, a hydraulically operated push bar is located above the cutter drum.

CHARACTERISTICS OF CLEARED AREAS

The flailing action of the 70 heavy cutter-arm assemblies almost completely reduces all shrubs, trees, or slash contacted to a mulch consistency. This action is more

fully described under the section on Cutting and Masticating in this report.

In almost all cases it can be said that the Tree Eater does an excellent job of clearing land of undesirable vegetation. The actual degree of reduction, however, depends on how close the cutters are operated above the ground. When the cutters are set to operate within two to three inches of the ground, cleanup is excellent; within four to six inches, cleanup is good.

Figures 3 and 4, below, illustrate work performed in ponderosa pine stands. Figure 3 is a dense stand of small saplings that was being strip-thinned, while figure 4 shows an old timber sale area where decaying logs and dry slash were treated with the Tree Eater.

Figure 3. Typical results during strip-thinning

Figure 4. Slash area treated by Tree Eater

In the slash area the terrain took on a fairly clean, park-like appearance. A similar degree of clearing could be accomplished on roadside zones, rights-of-way, proposed recreation sites, and fuel breaks.

Although plots being cleared of undesirable species - chaparral, juniper, and other shrubs - may not be cleared to the extent of the previous examples, (see figure 6) the degree of material reduction exceeds that produced by any other mechanical method now being used. Figure 5 shows a typical dense brush area with scattered pines and large Emory oaks that has been cleared in the foreground.

Figure 5. Brush area cleared with tree eater

In some cases it is desirable to leave larger trees to increase clearing production, provide shade and an aesthetically pleasing appearance, and to reduce costs. This will be covered in more detail later in the report, under Production Performance. Figure 6 shows an area cleared of standing junipers. The machine achieved nearly total mastication; but, because the cutters were not set at near-ground level, all of the lateral branches at the bases of the stumps were not removed.

Figure 6. Standing juniper plot after test

The Tree Eater was also operated in an area of cholla and Acacia graggii. Figures 7 and 8 show this operation.

Figure 7. Cholla plants before being masticated

Figure 8. Cutover area - note scattered cholla joints

All parts of the cholla cactus engaged by the cutters were ground to a green pulp. But, since propagation of this plant is primarily by regrowth of joints setting roots in the ground, those parts that escape the cutter and are not completely destroyed could become re-established.

OPERATING LIMITS

Maneuverability

During the field test an effort was made to establish safe operating limits for sidehill and up-and-down-grade operating conditions. The ground was dry, fairly loose, decomposed granite soil with scattered loose rocks up to 10 inches in diameter.

Sidehill operations should be limited to slopes of 20 percent and below. When the machine is operating on a side slope of more than 20 percent, any loss of traction by the downhill track (due to going over a rock, log, or loose soil) causes the front or back of the unit to swing downgrade, with a temporary loss of control.

When the machine is working downhill, grades should be limited to 10 percent. At grades above this figure, the operator could lose control of the unit. During this time it is possible to overload the cutting drum if a large tree is encountered. The major reasons for the control limitations are: (1) The Tree Eater approximately doubles the total weight that the Case 750 tractor's brakes must control; and (2), when the brake is depressed, the engine power (drag) is automatically disengaged on that track. An additional problem occurs when both brakes are used simultaneously. Since both brake pedals are operated with the same foot, it is impossible to control the amount of brake applied to each track when both brakes are being operated together. Grades steeper than 10 percent can be treated by working uphill and rolling (backing) downhill.

When working upgrade, the unit can be operated on grades of up to 35 percent. If only shrubs are encountered, it may be possible to operate on slightly steeper slopes. But when larger trees must be cut, it is not possible to slow the forward travel of the tractor enough to prevent overloading the cutter and still keep the tractor's engine speed up to prevent stalling. This 35 percent grade is also near the maximum for control while backing downhill. A higher ratio set of ring and pinion gears would increase control during this type of uphill cutting operation.

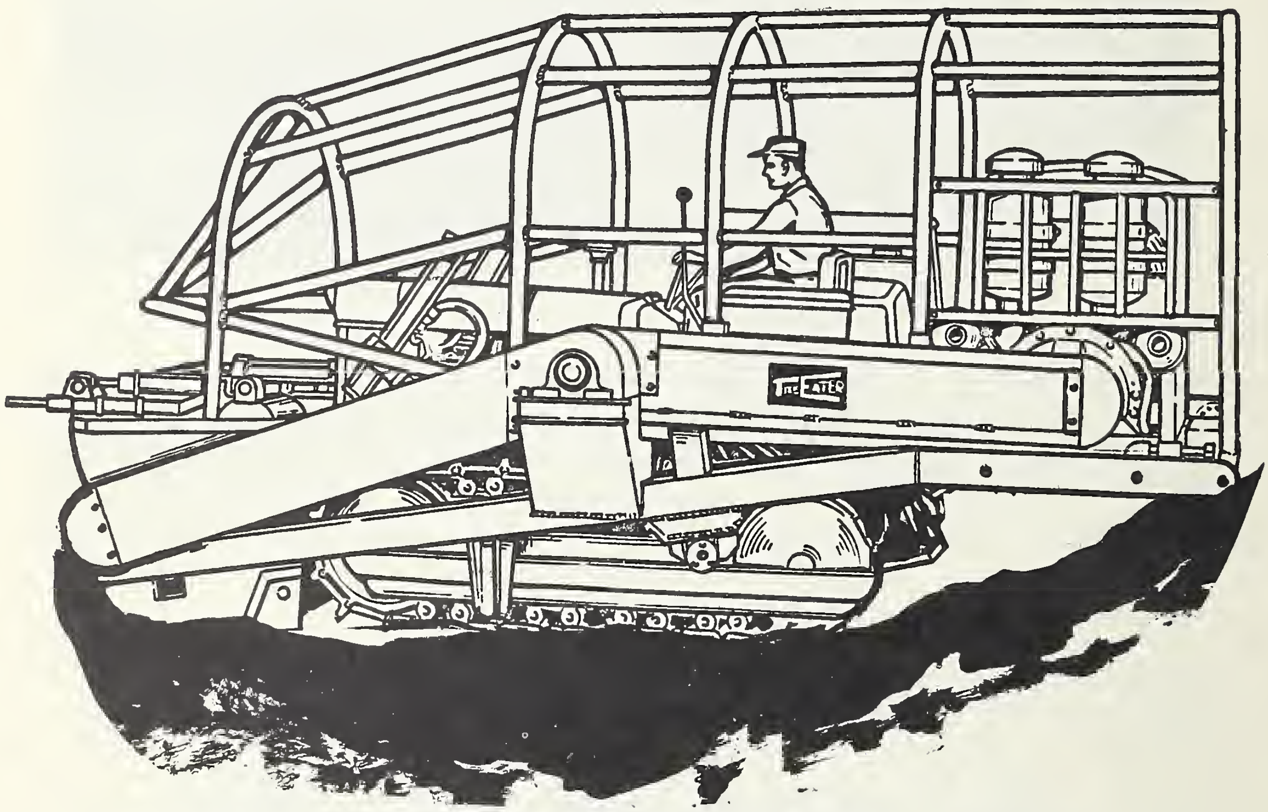

Figure 9. Illustration of how the Tree Eater can get trapped in a gully

Difficulties can also be encountered in areas with abrupt changes in slope created by ditches and gullies. When the machine crosses such areas, the additional overhang of the Tree Eater can cause the machine to hang up. The characteristic action for this is for the machine to enter a gully in a position perpendicular to its channel to the point where the cutter drum digs into the forward slope. When this happens, the operator raises the front with the hydraulic control. This, in turn, causes the back of the Tree Eater frame to drop because of rotation on the carrying pivot. If the machine cannot clear the forward slope, the loss of clearance of the rear overhang makes it almost impossible to back up the slope to the rear. Good judgment is required when working on this type of terrain, and even then the operation will necessarily be limited.

Areas containing outcroppings or large numbers of surface rock and boulders 4 inches in diameter or larger should be avoided or worked with care. These larger rocks will cause damage to the cutters. To avoid a majority of these hazards, the cutters should be set to at least 4 inches above ground level.

Cutting and Masticating

During the test and while in use over a 12-month period on the Tonto National Forest, the Tree Eater fully demonstrated its ability to fell trees and fully masticate all but the main stems (10 inches in diameter and over) of the larger, tougher species. Brush, including chapparal, and trees up to 6-inch stump diameter are almost completely shredded and reduced to a mulch consistency.

No limit has been determined for the maximum size of tree that can be felled with the machine. Oaks, junipers, and pines up to 24 inches in stump diameter have been felled during tests.

Figure 10. A 24-inch-diameter stump cut by the Tree Eater

Figure 11. Effects of flail cutters on 18-inch tree

The effectiveness of the Tree Eater's masticating and shredding action seems to be similar for both dead and green wood. The softer green woods - pines, pine slash, and most shrubs - produce long, fine shreds of material, while the harder species - including oaks, manzanita, and dry slash - are reduced to chips and splinters.

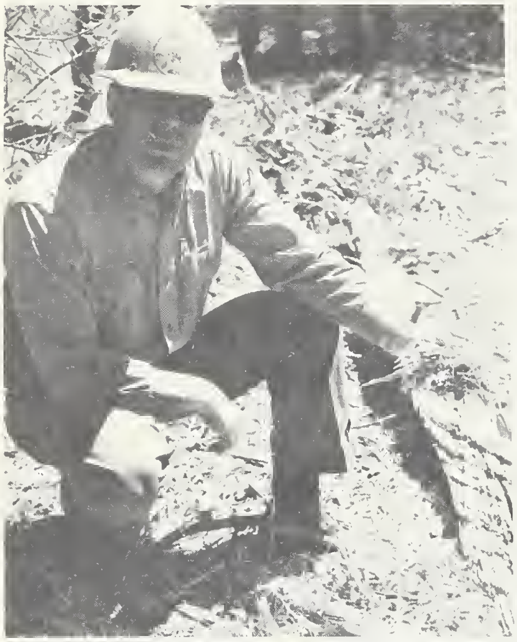

Figure 12. Long fine shreds produced in reducing green pine

Figure 13. Coarse debris from a shattered alligator juniper

Because of the need in some areas to run with the cutter set at 4 inches or higher for good bit wear and to prevent breakage due to rocks, some of the smaller stems may not be completely chipped once they are felled. For larger logs, only the exposed upper surface is removed and chipped.

Figure 14. Only the upper portion of an oak trunk was stripped off with a high cutter setting

Sprouting brush species cut at the 4-inch-plus height show considerable resprouting. Figure 15 shows the extent of resprouting and growth after the area was cleared with the Tree Eater. The time interval between the clearing operation and the condition shown in the photograph was two years. Where the resprouting is not desirable for cattle or game browse, it can be effectively controlled by chemical sprays because of improved access and the low height of the growth.

Figure 15. Resprouting after clearing with the Tree Eater

PRODUCTION PERFORMANCE

In determining the areas of specific use for the Tree Eater, it will be necessary to give careful consideration to probable production rates. Presently, within limits, production is more dependent on terrain and soil type than on ground cover. This statement is true for areas that do not contain stems over 6 to 8 inches diameter at breast height or where the stems above this size-class are avoided and left standing. The reason for varying production due to terrain is the additional time required to work only uphill on steep slopes and the extra time required to avoid gullies and having to turn in small plots. Numerous large rocks or highly abrasive soil, with dusty conditions, will require increased maintenance and cost and will result in reduced production.

For the current model of the Tree Eater working in decomposed granite under dry, dusty conditions, the estimated average machine operating time is 5 hours per 8-hour day. This would include the time required to replace worn cutting knives and skid shoes, fueling and lubricating the tractor and Tree Eater, and servicing the air cleaners. Through improvements to reduce wear or the design of expendable cutter bits and skid shoes and with the addition of centrifugal-type air pre-cleaners, it should be possible to increase the operating time to 6 or more hours per workday.

As with the present machine, this would require a two-man team - an operator plus an assistant operator for relief and swamping.

Production data presented in Table I were gathered on both small test plots of about one acre in size and from the pilot operation of the machine by the Tonto National Forest on four large plots up to 88 acres in size. More complete descriptions of the plots are presented in Appendix II. The production rates logged by the Tonto were lower in all but one case (slash disposal) than those indicated by the test. The high frequency of repairs and the maintenance time accounted for the lower production rates of the pilot operation. These factors were not included in the test plot data. However, because of current improvements and considering future recommended action to reduce engine and cutter-arm maintenance, production should increase to at least the higher figures shown in Table I. Also, under good working conditions of even terrain and less abrasive soil, production should increase in almost all cases to at least 1 to $1\frac{1}{4}$ acre per hour.

TABLE I

AVERAGE PRODUCTION RATES

Operation	Terrain and Ground Cover Conditions	Average Production
Pine slash disposal	Selective timber cutting; slash not piled	.8 to 1 acre/hour
Control of undesirable shrubs	Dense chaparral, juniper, and manzanita	.8 to 1 acre/hour
Control of undesirable shrubs	Dense chaparral and average of 30 trees - oak and pinyon - 8 to 14 inches DBH cut per acre	.5 to .6 acre/hour
Control of undesirable shrubs and trees	Dense chaparral and average of 30 trees - oak and pinyon - 8 to 14 inches DBH cut per acre. Extra time needed to work 25% of area with steep slopes up to 35% grade.	.4 acre/hour
Strip thinning	Doghair stand of ponderosa pine, 17,000 stems $1\frac{1}{2}$ inches average DBH per acre	.5 acre/hour (of cleared strips)
Juniper control	Trees either standing or cabled. Average 350 trees per acre, 35% canopy coverage.	1.2 to 1.4 acres/hour
Cactus control	Principally cholla, with mixed catclaw and mesquite	1.2 to 1.5 acres/hour

When working in areas that contain numerous large trees, it is necessary to decide whether to fell and masticate the trees or leave them standing. Trees up to 8 inches DBH present no real time delay for the machine to cut and fell. In most cases this can be done in less than 3 seconds. Additional time required to clean up the side branches and reduce at least 50 percent of the trunk is $\frac{1}{2}$ to $1\frac{1}{2}$ minutes, depending on the number of movements required to position the machine. Larger trees from 8 to 14 inches DBH and up to 20 inches stump diameter take up to 18 seconds to fall and from 1 to 4 minutes to chip the side branches and 50 to 70 percent of the upper trunk. Further reduction to 10 percent of original volume can require up to 8 minutes.

COST

When considering the maintenance and the labor cost for the operation of the Tree Eater, it is necessary to realize that the unit is really made up of two machines - the tractor and the masticator (Tree Eater). Each machine has its own engine and drive train, both of which require fuel and maintenance. During the pilot operation the Payson District of the Tonto National Forest maintained cost and production data. A summary of these data is presented in Appendix III.

During approximately 423 hours of operation the average hourly cost of operating the Tree Eater was $20.58. This figure includes fuel and oil, parts and repairs (including rebuilding of cutter bits), mileage on the $\frac{1}{2}$-ton pickup, and labor (operator and swamper). It does not include depreciation or a machine rental cost. Because of early belt failures and the short wear life of the cutters, the maintenance cost for these items was extremely high - approximately $3,400, or just under $8.00 an hour. By using Gates PowerBands to replace the V-belt drive, improving cutter wear by working under more favorable soil conditions (less abrasive and with fewer surface rocks 4 inches in diameter and larger), and using harder rod in rebuilding the cutting bits, it should be possible to reduce this cost by at least one-half, or to less than $4.00 an hour. If this reduction is realized, the hourly operating cost would be in the neighborhood of $16.00, plus depreciation. With these high operating costs, it is necessary to maintain as high a production level as possible. This is best done by a careful selection of the work areas and the reduction of as few trees over 8 inches DBH as possible, while still performing the required work to an acceptable standard. During the pilot operation a production rate of $\frac{1}{2}$ acre per hour meant a cost of $41 per acre; a rate of 1 acre per hour meant a cost of about $20 per acre. Since the Tree Eater does a complete job with little or no follow-up work required, the cost per acre appears to compare favorably with that of other methods of intensive clearing.

MECHANICAL WEAKNESSES

Belt Drive

When the Tree Eater was delivered to the Forest Service, it was equipped with two sets (front and back) of ten matched individual V-belts. In less than 100 hours of operation the first set of belts had to be replaced because of breakage. After 134 total hours of operation (including time on the first set), several belts of the second set had become so damaged they had to be removed before they broke.

There were two major reasons for this extremely short belt-life, both causing the belts to turn over and run upside down. The first cause was the imposing of severe

Figure 16. Guards off, showing both front and rear sets of belts

pulsating and shock loads on the belts by the inertia of the cutter drum and the high torque of the engine. Under these conditions V-belts will whip laterally and enter the sheave grooves at an angle, causing them to turn over or even come off the sheaves. The second cause for belt failures was related to small sticks and other trash collecting in the belt guards and eventually working between the belts and sheaves. This trash entered through the coarse $\frac{1}{4}$-inch-mesh screened areas provided by the manufacturer for ventilation, as well as through loose-fitting joints in the belt guards. To overcome this problem the operator added a fine-mesh window-screen material over the existing screens and sealed all other openings as well as possible.

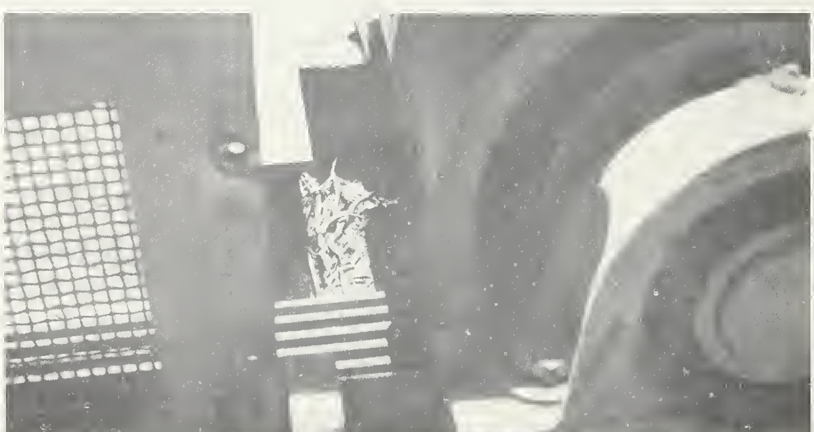

Figure 17. Trash in belt area that could cause belt damage

In order to overcome the belt-whipping problem the Tree Eater manufacturer recommended the use of the Gates Rubber Company's "PowerBand" belts. PowerBands are made by joining together several V-belts with a permanent high-strength tie-band. The tie-band forms a firm backing for the belts and ties them together to prevent belt flipping. For the Tree Eater the most suitable number of V-belts per PowerBand is five, so that a set of ten single belts is replaced with two PowerBands.

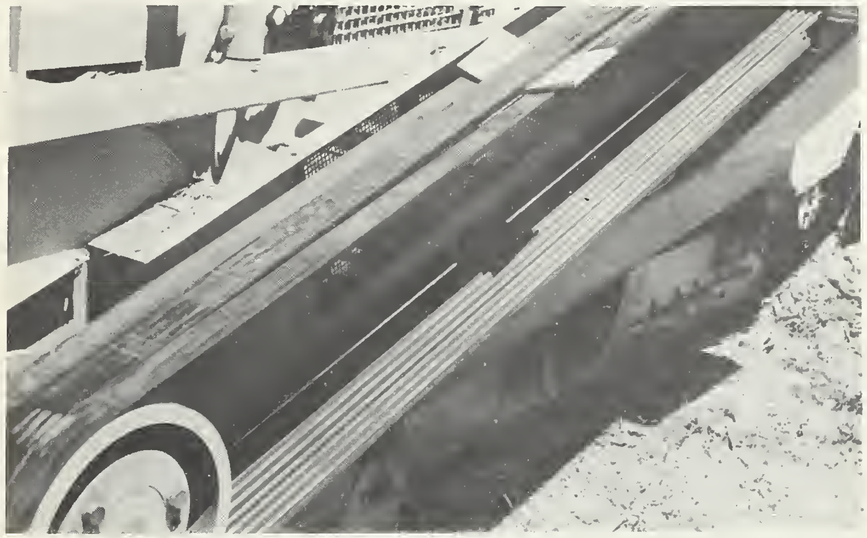

Figure 18. PowerBands made up in a set of 3-4-3

When the PowerBands are properly tensioned - as outlined in Appendix IV, "PowerBand Tensioning Kit Instructions" - and all trash is eliminated from the belt guards, good service life can be expected. At the end of the evaluation period the second set of PowerBands had over 174 hours of use without any notable problems. The first set was destroyed by a freak accident caused by a heavy limb being forced into the belt guard, bending it into the belts.

Figure 19. Broken belts resulting from guard being accidentally pushed into the PowerBands

A full set of PowerBands for the Tree Eater costs $450, as compared to approximately $350 for a complete set of twenty single V-belts. The indicated increased service life of the PowerBands would justify their higher cost.

Cutting Arm Assemblies

Maintenance of the cutting arm assemblies can be the highest single maintenance cost item for the Tree Eater. However, through careful operation, proper cutter-to-ground clearance, and proper maintenance, the cost due to wear and breakage can be held to a reasonable level. Proposed design changes by the manufacturer will also be aimed at reducing cutter maintenance cost.

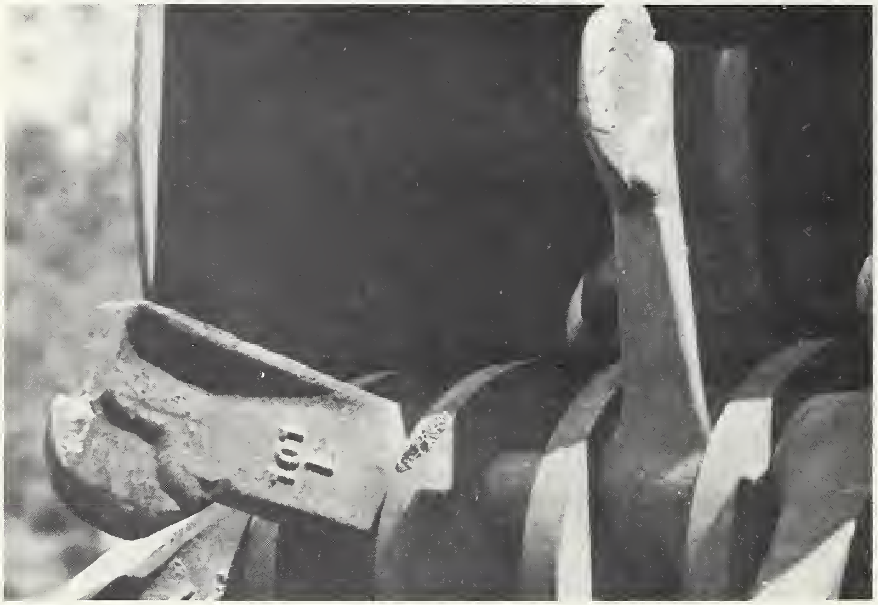

Figure 20. Closeup of badly worn cutters

When the cutting drum is up to operating speed (1,800 rpm), the cutter bits or knives on the ends of the arms are traveling at a rate of approximately 17,000 feet per minute (approximately 190 mph) peripheral speed. Thus the flailing action of the 14-pound cutting arms can only be a brute force process. Under these conditions the cutters are bound to continue to sustain wear and damage in rocky, abrasive soils.

During the pilot operation, wear, not breakage, was the biggest problem with the knives, although some breakage did occur. When working in dry, abrasive soils, such as decomposed granite, with the cutters set to within 2 to 4 inches of the ground, wear can only be termed excessive, as illustrated by Figure 22.

This wear is caused by a sandblasting effect created by the high velocity of the cutters as they pass through the clouds of soil particles and rocks surrounding the front of the machine, as shown in figure 21 This condition seems to be a greater factor than the type of wood or the size of trees and shrubs being cut.

Figure 21. Cutting drum being subjected to sandblasting effect

Figure 22 shows the wear pattern for a new knife (not rebuilt with hard-facing) that was on the machine during the 1966 field test. As shown, the rate of wear decreases at a fairly rapid rate as the sharpness of the point and edge is lost. Rebuilt bits showed similar wear characteristics to those of new bits. During a 9-hour test period represented by figure 22, the cutters were subjected to about the worst operating conditions that would ever be encountered.

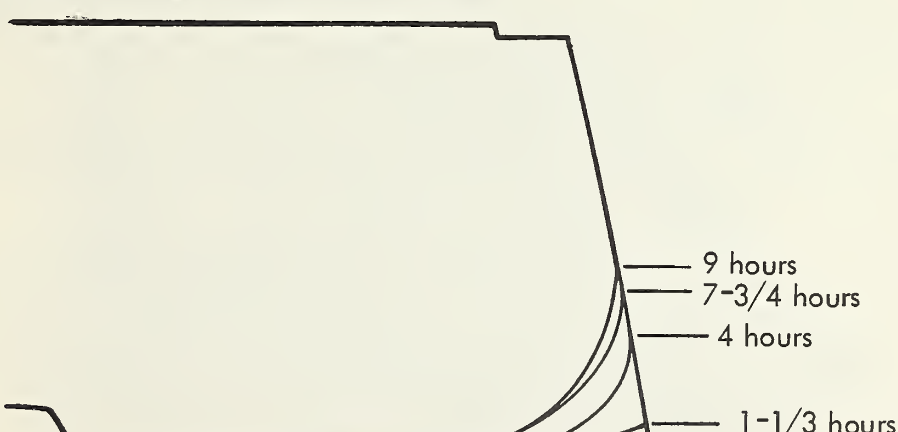

Figure 22. Wear pattern for a new cutter bit when working in decomposed granite soil

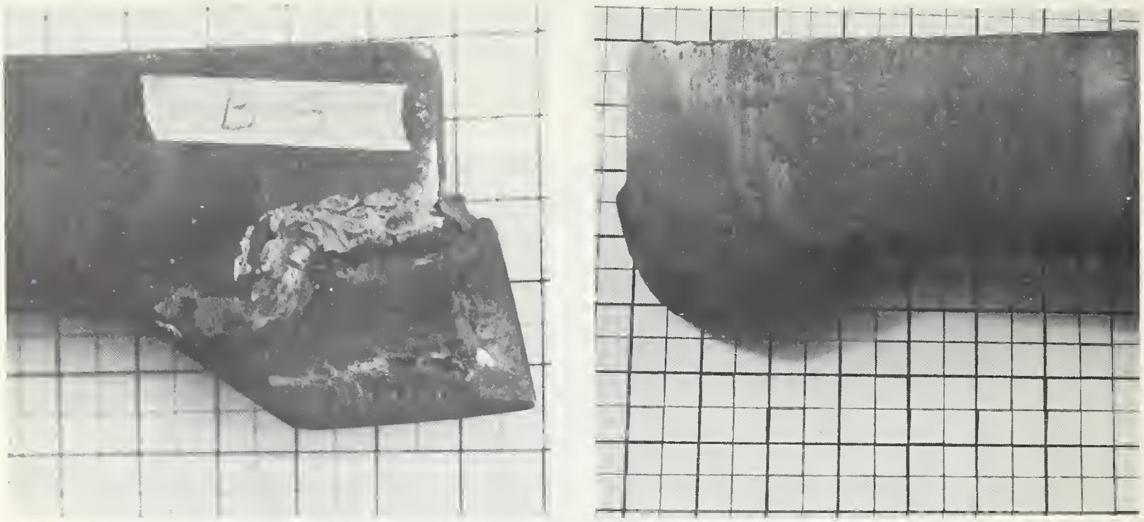

Figure 23. Comparison of new cutter (left) and badly worn one (right)

During the pilot operation the average life of the cutters, before being rebuilt, was approximately 40 hours. One set of rebuilt cutters lasted only 20 hours. This set was built up by using alternate passes of hard rod (Airco 388 or equal) and low hydrogen rod. In contrast, one other set of rebuilt cutters lasted approximately 90 hours when working in an area for the disposal of dry pine slash lying on a clay-type soil. The type of hard-facing for these knives is not known.

Considering the short life of these knives and the fact that no noticeable chipping or cracking of the hard-facing has occurred, it should be possible to go to a harder facing material. One system that may extend the life of the knives would be to use a rod similar to Airco 388 (52 to 55 Rockwell "C") for buildup, then follow with a final pass of Airco Easyarc 620 (approximately 65 Rockwell "C") or equal for the hard-facing. If chipping occurred, a lower hardness rod in the range of 60 Rockwell "C" could be used for the hard-facing. The aim should be to extend cutter life to at least 100 hours under severe operating conditions.

The minimum welding shop cost for rebuilding a set of 70 cutters was $140.00 in the Payson-Phoenix area. This figure could vary, depending on locality. A new set of 70 cutting arm assemblies cost about $1,000.

Also, the number of times a cutting bit can be rebuilt seems to be limited. A set of cutting arms that have had the knives rebuilt four times showed a tendency to break at the arm-to-bit weld as well as for the bits to break more frequently. After the third rebuilding the old bits should be cut from the arms and new bits welded on. These problems could also be overcome by developing cutter arms that would accept replaceable bits held by a mechanical means.

Figure 24. Arm with missing bit

Other Major Wear Points

During early use of the Tree Eater it was noticed that excessive wear was occurring to the skid shoes that support the cutting drum. Although the shoes were made of 3/4-inch steel, they wore completely through in 118 hours of use. For repair the operator designed soleplates (of $\frac{1}{2}$-inch steel with solid hard-facing laid on the bottom surface) that are mounted to the shoes by four $\frac{1}{2}$-inch-diameter studs. Even with

Figure 25. Hard-faced skid shoe with soleplate added for increased life

the solid hard-facing these soleplates lasted less than 20 hours when working in decomposed granite. The operator then secured a piece of old snowplow blade 3/4 of an inch thick, fabricated a new set of soleplates, and mounted them to the skid shoes. These wear plates lasted for about 52 hours of operation, or about three times longer than the hard-faced soles.

What appears to be excessive wear also has occurred to the track rails of the Case 750 tractor. If the wear persists at the observed rate, it is possible that the rails may have to be replaced after the second or third season's use. The wear is attributed to the combination of the abrasiveness of the D.G. soil and the heavy weight of the Tree Eater that must be carried by the tractor.

HEALTH AND SAFETY

Considering the nature and function of the Tree Eater, it should be expected that some health and safety problems will occur with its use. Within the first 100 hours of use on the Tonto National Forest, it was apparent that an operator could not tolerate the dust condition created by the unit. The natural dust-producing, dry-soil conditions of the Southwest, linked with the high speed rotation of the flails, combine to engulf the machine and operator in a cloud of dust.

Figure 26. Dust condition existing around Tree Eater

From figure 26 it can be seen that the dust is of sufficient density to obscure the operator's vision from time to time, particularly when he is working downwind. This makes it necessary that a swamper or relief operator always be present to help guide the operator from the sidelines. During the test it was easy to see that some form of radio communication should be provided under these conditions. The noise level of the machine is too high (over 95 decibels) for vocal commands, and vision is sometimes impaired. Although a complete analysis was not made during the test, the level of 90 and 95 db on both the B and C weighing scales was common at distances of from 40 to 80 feet from the unit. This would place the actual sound

level above 95 db at the operator's seat. Current Noise Control Safety Orders issued by the State of California, Department of Industrial Relations, specify a maximum noise limit of 95 db for 5 to 8 hours of exposure.

Besides limiting vision, the dust cloud would seem to present a potentially serious health hazard. To establish the extent of the hazard, tests would have to be run to determine the free silica content of the soil and the actual dust concentration at the operator's position. In a test by the California Department of Public Health, figures shown for a brush-clearing job done with a D-7 dozer during warm, dry weather exceeded the safety standards by more than tenfold.

To help protect the operator, an Air Boy helmet (Jo Art Industries, Box 8127, Stockton, California) with filter system was added to the machine. This unit definitely reduced the dust hazard to the operator but also reduced his efficiency. The helmet further reduced the wearer's contact with the outside world by impairing both hearing and vision. Also, it is necessary for the operator to take breaks or rotate with a relief operator just to get out from under the "hat." Frequent, careful cleaning of the clear face shield is also necessary to keep light diffraction to a minimum.

Although no fires have been started by the Tree Eater, this possibility is always present. The fire risks are in two categories. First, there is the danger of machine fires. These can occur, and have occurred, from several sources. With the large electrical current available from the four 6-volt batteries, almost every short (in circuits not protected by fuses) will cause wire insulation and any other flammable material in the vicinity to blaze instantly. There is a large quantity of airborne debris from the cutting and shredding of dead wood by the flails. This material very often lodges around the exhaust system of the engines (two in this case). There it could ignite and then fall onto the engine belly guard, where there is more fuel to burn. A good high-capacity (6 BC rating or higher) fire extinguisher should be mounted on the tractor within easy reach of the operator.

Secondly, it is recognized that with all crawler tractors there is the danger of fire from sparks caused by the tracks slipping on rocks when the weather and forest fuel conditions are right. The danger of spark-caused fires is compounded when the Tree Eater's cutters encounter rocks, as they often do. At such times a stream of sparks is given off to shower down on ground fuels. However, it is possible that many sparks are extinguished by the air and soil thrown at high velocity by the rotating cutter drum. Although this potential exists, no evidence of such ignitions was observed during the tests.

CONCLUSIONS

Favorable Points

Within the limitations described in Problem Areas of this section the Tree Eater has demonstrated that it can do an excellent job of clearing land. The degree of material reduction exceeds that produced by any other mechanical methods now being used. However, where sprouting species are present it may be desirable to use herbicides as a secondary treatment.

The Tree Eater's effective masticating and mulching should make it a useful resource management tool. Uses could include Timber programs for release, thinning, and slash disposal; range and watershed programs for improving livestock forage; wildlife habitat and water yield by clearing during type conversion projects, as well as right-of-way clearing and the manipulation of vegetation or fuel reduction when preparing fuel breaks.

The unit is rugged and is capable of felling both green and dead trees up to at least 24 inches in stump diameter, although this may be economically impractical.

It appears from test data that production rates of up to one acre per hour or more are possible with the Tree Eater if the terrain consists of slopes of 20% or less and if trees of 8 inches DBH and over are avoided. This, linked with decreasing maintenance to the cutters and cutter drive train, indicates that a cost of $20.00 to $30.00 per cleared acre should be realized.

Problem Areas

Care and good judgment must be used at all times when operating the Tree Eater. The unit shows signs of being overweight for the tractor and has a high center of gravity. Side slope work should be limited to 20%. On downhill operations, in the presence of large trees or rocks, work should be confined to slopes not exceeding 10%. No difficulty was encountered in working up 30% slopes. Abrupt changes in slope created by ditches and gullies must be avoided to prevent the machine from getting hung up. Also, because of the increased ground pressure on the tracks (approximately 9.5 psi) caused by the added weight of the Tree Eater, consideration should be given to the load-bearing properties of the soil in the project area and the influence of weather on those properties.

Present maintenance costs are high. Improvements have been made in some areas of the drive train, but more work is needed to reduce breakage and wear of the cutters and cutter drum assembly and to increase the service interval for the air cleaners under dusty conditions.

The machine produces more than its share of health and safety problems. Work is needed to improve operator working conditions and to reduce the possibility of fire and mechanical damage to the unit.

RECOMMENDATIONS

On the basis of present information the Tree Eater cannot be recommended as a general large-scale land-clearing machine. When the unit is considered for use, careful study should be made as to the degree of clearing desired, size of trees or shrubs to be cut and masticated, and terrain limitations. Within the limitations outlined in the report, the machine can be used to good advantage. is

If the machine is to be worked in any area that may present a dust problem, it is recommended that the unit be equipped with an air-conditioned cab that will protect the operator from dust and noise. At least the front windshield should slope inward at the bottom to reduce dust collecting on the outside surface. Two-way radio communication is recommended for use between the operator and the swamper. To safeguard the machine, a solid steel belly pan should be provided under the GMC diesel

engine. The engine should be provided with low oil pressure and high temperature cutoff switches. A high-capacity (6BC or over) fire extinguisher and shovel should be mounted within easy reach of the operator.

The GMC engine should be provided with a qualified spark arrester.

More work is needed to reduce the cost of maintenance on the cutters by improving their wear characteristics or providing easily removable bits. If available for the Case 750 tractor, a higher ratio (low-speed) ring and pinion gear should be used to increase engine braking on downgrades.

APPENDIX I

GENERAL TREE EATER SPECIFICATIONS

Manufacturer	Tree Eater Corporation Gurdon, Arkansas
Total Weight	Approximately 25,000 pounds
Length (overall)	17 feet 6 inches
Height (to top of canopy)	10 feet 6 inches
Width	8 feet
Power Unit (cutter)	325 hp 8V-71 GMC Diesel Engine
Cutter (flail)	72-inch-long drum 30 inches in diameter with 70 14-pound cutting arm assemblies in four rows
Cutting Height (free floating)	0-8 inches, adjustable skids
Cutting Height (hydraulic-controlled)	0-27 inches above ground level
Cutter Drive Train	Dry-plate clutch and multiple high-capacity V-belts (Gates PowerBands)
Electrical System	24-volt DC; four 6-volt batteries
Prime Mover	Case 750 Crawler Tractor, weight approximately 14,000 lbs.
Engine	70 hp A-267-D Case Diesel 215 lb. ft. torque at 1300 rpm
Transmission	Terramatic 4-speed Hi-Lo selector type (power shift - power shuttle)
Torque Converter	Single-stage hydrokinetic type (2.92 to 1 ratio)
Hydraulic System	Closed circuit - pumps constant-drive, gear-type driven from engine crankshaft. 28.5 GPM @ 1900 rpm, 1250 psi, relief setting
Tracks	18-inch width (area 2626 sq. in.)

APPENDIX II

TEST PLOT DATA

Work Type	Terrain and Ground Cover Data	Plot Size	Average Production
Slash disposal – 1964 test plot	Two-year-old pine slash from selective cutting; 909 cubic feet per acre dead material as slash, snags, and down trees. Level ground.	.5 acre	1 acre/hr.
Pilot operation 1966	Both dry and green slash from pulp wood operation. Moderately heavy slash (averaging 90 sq. ft. basal area after cutting). About twenty acres of area was thinning saplings and pole-size material.	88 acres	.[illegible] acres/hr.
Eradication of undesirable trees and shrubs Test Plot #1 1966	Test plot contained both trees and shrubs. Shrub species included manzanita, juniper, and chaparrals in a height class of 2 to 6 feet. Trees included Emory oak and mature juniper up to 16 feet in height and 13 inches DBH. Density 70%. Soil, decomposed granite. Approximately 50% of area worked was on 20% side slope, and 35 trees 7 to 13 inches DBH felled and chipped.	.9 acre	.6 acres/hr.
Eradication of undesirable trees and shrubs Test Plot #2 1966	Test plot contained both trees and shrubs similar to Test Plot #1 above. Majority of shrub species 6 feet in height and under. Stems 8 inches DBH or requiring more than 0.2 minutes to fall not included.	1.1 acres	.[illegible] acre/hr.
	Same plot as above, only including the times to fall and limb trees of 8 to 14 inches DBH. Average 30 trees per acre. Slopes to 20%.	1.1 acres	.5 acre/hr.
Eradication of undesirable trees and shrubs Test Plot #3 1966	The test plot was on level ground. Although the plot contained many large trees and stumps, these were avoided to maintain reasonable production.	2.4 acres	.7 acres/hr.

APPENDIX II (Cont.)

TEST PLOT DATA

Work Type	Terrain & Ground Cover Data	Plot Size	Average Production
Strip-thinning of pine stand 1964	Ground was level and contained a doghair stand of ponderosa pine. Stems of 1.4 inches DBH averaged 17,000 per acre, with a basal area of 180 sq. ft. per acre. Average tree height, 10 ft. Area was logged 9 years before the test.	1 acre	.5 acre/hr. (cleared)
Juniper eradication 1964	Standing junipers 124 alligator junipers per acre (sprouting) 260 other junipers per acre (non-sprouting) 52 pinyons per acre 436 trees per acre Average height 8 ft. Range 2 to 24 ft. Average crown 6 ft. 30% canopy coverage	1 acre	1.5 acre/hr.

APPENDIX III

Summary of production and cost figures for 1966 pilot operation as supplied by the Tonto National Forest.

Summary of Cost

		Cost to Date	Avg./Hr.
Maintenance			
Parts and repairs		$2,534.52	$5.98
Cutter rebuilding		840.00	1.98
	Sub-total	$3,374.52	$7.96
Operation			
Fuel and oil		$ 773.55	$ 1.82
Mileage		235.95	.56
Labor		4,339.70	10.24
	Sub-total	$5,349.20	$12.62
Depreciation (estimated)		$2,904.40	$ 6.85
	Total	$11,628.12	$27.43

Summary of Operations

Area	Acres	Hours	Acres/Hr.	$/Acre*
Mud Springs (Chaparral)	65	135	.48	42.74
Study Area (Chaparral)	30	61	..49	41.85
Thirteen Ranch (Slash)	88	93	.95	21.75
Houston Mesa Rd. (Chaparral)	70	135	.52	39.69
	253	424	.60	$34.48

*Not including depreciation

Note: The high cost of parts and repairs reflects the early failures of the individual V-belts. The use of the PowerBands with proper tensioning has reduced these failures. The high cost of knife rebuilding is due primarily to the fact that about 78% of the machine-operating time occurred during cleaning chaparral plots with highly abrasive D.G. soil.

APPENDIX IV

POWERBAND TENSIONING KIT INSTRUCTIONS

The kit consists of a spring scale, a tee handle, two force plates, and a sleeve assembly for the scale push rod. To use, several holes must be drilled in the Tree Eater belt guard assemblies. One hole must be drilled over the center of each PowerBand at the midpoint between the pulley centers. Approximate hole diameters should be $\frac{1}{2}$ to 9/16 of an inch. As a temporary means for covering the holes after tensioning, the holes in the belt guards can be sealed, using a fabric tape. A more suitable means should be devised to prevent foreign matter from entering the belt guards. After locating and drilling the holes in the belt guard assemblies, assemble the tee handle to the scale by the use of two bolts which are provided. Select the proper width force plate that will just span the width of the PowerBand to be checked. The edges of the plates are marked with numerals indicating the number of V-belts per band. Position the force plate on the PowerBand and insert the scale push rod through the proper belt guard hole and into the force plate boss. Place the scale in the vertical position and move the slide assembly to the position with the zero line lined up with the top of the guard surface. Position the "O" ring on the slide assembly to indicate the desired belt deflection. Check the position of all components. By use of the handle, supply force to the scale to the desired loading (15 pounds per V-belt) and note the deflection as indicated by the slide assembly. Adjust the band tension until the proper deflection is obtained for the given force. The belt deflection for proper tension is 1/64 inch per inch of span between pulley rims at the point of the belt to rim contact.

Belt tensioning kit made up by Equipment Development Center

Spring scale in position as if applying force to PowerBands